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STUDY OF CERTAIN FEATURES OF THE LAWRENCE SHALES.

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DURING the development of the economic resources of southern Kansas some rather interesting facts have been noticed and commented upon from time to time by those who have studied the surface of the country, especially those who live in the area of the gas belt, this territory having been hastily crossed by geologists and certain facts noted, such as numerous mounds, and reddened sandstone, as though it had been burned. Sandstone dipping twenty to thirty degrees, and at one place quartz crystals abounding, caused our state geologist to send me to study these facts and to ascertain, if possible, the causes therefor. The first place studied was the so-called "Silver City."

I found Silver City to be situated nine miles east and two and one-half miles south of Toronto, in section 29, township 26, range 15, and owned by George Hill. Geologically it is a part of a high escarpment caused by the vast stratum of massive sandstone which lies just beneath the Oread limestone that marks the upper boundary of the Lawrence shales, this escarpment being quite conspicuous for many miles both north and south of this place. To the east is a small creek called West Buffalo, heading some six miles northeast, Big Sandy being some miles to the west. Here we find in the place of the layer of massive sandstone a stratum of quartzite for almost one mile, extending along the brow of the escarpment, which runs here in an east and west direction. On top of the hill the surface is level for several miles looking to the northwest. Beneath this stratum of quartzite is approximately 150 feet of shale, and then appears a layer of blue limestone from two to three feet in thickness, very hard, of conchoidal fracture, and containing very few fossils, the paucity of which is very noticeable.

Some 300 yards south of the western limit of the quartzite layer the blue lime is found to be filled with vertical veins running in every direction, varying in thickness from something over one to a few inches, extending through the entire layer. They are apparently fissure-veins. The surrounding lime shows a very marked contrast in appearance to that of the vein stuff, and weathering greatly heightens this effect. Immediately above the lime the shale is very black and hard. Here and in the quartzite many holes have been dug prospecting for silver in the boom days of the place, hence the name "Silver City."

Along east and south of Silver City ridges and mounds capped with sandstone are noticed, the valley being some two miles wide. In the tallest mound, two or three miles southeast, I found a thin layer of lime—probably that has only a local occurrence, since I failed to find it anywhere else.

It seems that there are two important layers of sandstone in the Lawrence shales from Silver City to the state line, and in the shale separating them a thin stratum of very blue, hard limestone is found which serves the purpose of easily locating the sandstone layer; the upper stratum of sandstone forming the escarpment in this formation; the under layer forming the many mounds in the eastern part of the Lawrence shales. The blue limestone was seen in many places, from two miles northeast of Yates Center to several miles west and south of Elk City, and without doubt is permanent within the boundary given. The extent north and south of these limits is undetermined, but I suspect that this lime is continuous in this position. A similar lime in the same position is found west of Ottawa.

The upper massive sandstone is from ten to thirty feet in thickness, and beneath this is a clayey shale. This, being softer than the sandstone above, is eroded faster, and therefore the escarpment is usually very rugged, the sandstone outcropping in cliffs often twenty to thirty feet in height, and in some instances more. Also, in many places massive boulders have tumbled down from the sandstone, thus making this formation very picturesque and the scenery very rugged and beautiful. This is especially noticeable where a spring, which is very common in this formation, appears in the soft clayey shale beneath the sandstone, or where a stream has eroded away the softer material and the firmer sandstone has slipped down the hillside as a great landslide or has gone down as massive boulders. In some places the sandstone from the erosion of the shale forms an overhanging wall, the so-called caves of this region. True caves are found only in limestone formations. Many springs are found flowing from the clayey shale beneath this massive sandstone. The water of these springs is of exceptional purity, as shown by many analyses in volume VII, Geological Survey Reports, and forms one of the attractive features of this section of the state. The "Delaware Springs" is a noted example. Wells dug in this region also furnish very excellent soft water. The explanation is very simple. The coarse sandstone being nearly pure sand, cemented by oxid of iron, both of which are insoluble, therefore the water is practically as soft and pure as cistern water.

The soil formed from the decomposition of the sandstone formations gives a poor soil on the ridges for agricultural purposes, but is adapted to fruit-growing and some vegetables.

Both the sandy formations, but especially the upper one, are covered with a shrubby oak called "Black Jack." This often affords a means of seeing for miles the trend of the formation.

Many mounds are found, especially east of the upper sandstone escarpment. In these mounds, especially around Elk City and Niotaze, the sandstone which caps them is often found dipping and fractured in one direction for a few rods, and then in another—for example, the Oliver mound, two miles west of Elk City. In going from the valley to the top of this mound we pass first over shale, then over the blue limestone about fifty feet above the river bottom, then again shale, then the massive sandstone, which is found to be broken and dipping towards the hill. Here are found three benches, the sandstone capping each. Considerable quarrying has been done in each bench, and thus an opportunity is afforded for accurately observing the lay of the sandstone. In the highest part of the mound, that is, the highest bench, the sandstone was found to be horizontal, but in the others to be greatly disturbed. However, an examination showed that the blue limestone was undisturbed and on the same level in this mound as in the others in this vicinity, showing that the disturbed sandstone was local and caused by the soft, clayey shale underlying the sandstone pushing out and being eroded away, thus causing the massive slides in the hard sandstone above the shale.

Another example is the mound one mile north and west of Elk City. This mound has the appearance of a "hogback" from the river bottom. When going onto this mound at the lowest point we find a heavy layer of sandstone horizontal, capping a narrow ridge, say thirty feet wide. Going southeast for 300 yards to a point some twenty feet higher, we find the characteristic blue limestone on the same level as in the Oliver mound. The layer of sandstone five to ten feet thick is the sandstone found always under the blue lime. Going northeast, to the highest part of the mound, we find the sandstone dipping sometimes in one direction and then in the opposite. However, the blue lime was traced all around the mound and found to be undisturbed, save in a few places, where it was evidently covered by sandstone from above; or in some instances landslides have pushed the lime down the hill; but in all cases this effect was evidently local. As seen, some of the quarries here show that the sandstone has slipped down because the sandstone layer gives out, leaving a facing of shale.

About four miles southeast of Elk City, across the river at the ford, the first mound reached, many layers of sandstone are found dipping forty degrees south, and on the south side of the mound we find the same strata dipping north at about the same angle, the mound running mostly east and west. Little quarrying has been done in this mound and the examinations were not so complete as in the others, but sufficient to make it clear that this did not differ from those described.

Many mounds are found near Niotaze, to the east, north and south. The most interesting one, geologically, is the one part of which is in the north end of the town of Niotaze.

This mound contains about 100 acres and is mostly owned by Mr. Dobbs. In this mound many quarries have been opened and a good opportunity is afforded for the study of the strata. It will be observed that the strata become more horizontal as one reaches the summit of the ridge. The ridges and mounds west, north and south of this mound contain a similar layer of sandstone and in exactly the same position, and at no greater change of level than the normal dip. It will be seen that the general dip is to the southwest. No strata of sandstone is found appearing anywhere save on top of the hills, and a careful inquiry after records of wells in the west part of town, which is in the valley between this mound and the next ridge, showed that no sandstone was reached.

Many mounds were examined, but the above description is a fair sample of all.

Streams sometimes flow along the base of this formation, thus giving on one side of the stream an entirely different soil from the other, and upon a superficial examination leading to an erroneous impression concerning the phenomena. An example of this is found at Elk City, where the Garnett lime is found east of Duck creek and the soil is calcareous, while west of the creek the soil is sandy from the sandstone in the mound and the sandstone escarpment. An examination of the wells on the west side of the creek showed that they reached the Garnett lime and that it had the normal dip to the west.

In no instance was any strata in any of these mounds found to have a dip greater than the general dip, but that a careful study of all the phenomena showed plainly that it was caused by a landslide facilitated by erosion or by cross-bedding.

DIPPING SANDSTONE.

The upper massive sandstone in the Lawrence shales is found to be dipping in many places. Generally the dip is toward the center of the range or away from the escarpment. Also, the dip is, wherever examined, greater in the lower layers of sandstone, beneath which is a soft clayey shale, than in the upper ones. A cross-section of this dipping sandstone is sometimes seen in quarries, but the best examples I saw of it were in a large quarry one and one-half miles northeast of Yates Center, and in quarries along the escarpment from Mr. Soward's, two miles up the river from Oak Valley, to a deep railroad cut two miles east of Longton. A description of the appearance in this cut will suffice for all.

The sandstone which is the upper one is found to be very much distorted in this cut. Upon entering it at the west end, we find at the north side the strata dipping forty degrees to the west, and a few feet farther dipping at the same angle to the east. On the south side the underlying shale appears as though pushed up and separating the sandstone, which dips the same as on the north side. Where the shale has pushed up into the sandstone the twisted and contorted structure was noticed, and also the dipping sandstone. This cut is 200 yards long and the shale is pushed up into the sandstone six times in this distance to a height of from four to six feet above the railroad track, and at each place the phenomena of the sandstone is similar. The extent of the sandstone below the road-bed was not determined. The appearance is that the sandstone is broken and the shale pushed up, while the massive sandstone has settled down into the shale. The cut is from thirty to forty feet deep and the layers of sandstone become more and more horizontal as the top layers are reached. However, this seems to be generally true of all the dipping strata.

I concluded that all the dipping sandstone is from cross-bedding, massive landslides, or an uneven surface upon which the sandstone was originally laid down, the Longton railroad cut being an example of the latter. The mounds are all caused by erosion.

The reddened sandstone is caused by the changing of the iron coloring agent from the ferrous to the ferric state. All the different strata were found to be in place. Some low anticlinal and synclinal folds were noticed. In the anticlinal folds the massive layer of sandstone is often broken and the sides of these fissures faulted from one to six inches, as may be seen in the sandstone quarry one and one-half miles north of Yates Center.